NWA 480/NWA1460

Basaltic Shergottite

28 + 70 grams

***Figure 1**: Photograph of NWA 480 kindly provided by Bruno Fectay and Carine Bidaut.*

Introduction

NWA 480 was found in November 2000 in Morocco (Barrat *et al.* 2001, 2002; Grossman and Zipfel 2001). It was almost completely covered with fusion crust (figure 1) and appeared to be rather fresh with only a few spots of weathering products on the surface. Apparently, NWA 480, was sold to the National Centre for Space Studies (CNES), where it is "*being put to use to prepare for analysis of samples returned by planned missions to Mars" (according to Philippe Gillet*) and is being studied by *Consortium Théodore Monod*.

In December 2001, **NWA 1460** (70.2 grams) was acquired in Agadir, Morocco (Irving and Kuehner 2003). This sample is also covered with a complete fusion crust and appears to be paired with NWA 480 (*preliminary assessment based on comparison of figure 1 with figure 7*). However, the name NWA1460 apparently must only be considered "provisional", until this rock is described in the Meteoritical Bulletin.

Both stones are surrounded by a fusion crust, such that they must have entered Earth' atmosphere separately - as in a shower. One might hope that additional stones form this shower will be found.

Petrography

This meteorite has a coarse-grained basaltic texture consisting predominately of subhedral to euhedral pyroxene (up to 5 mm) and interstitial, lath-shaped maskelynite (Grossman and Zipfel 2001). Beck et al. (2004) have performed a detailed study of Li concentration and isotopic composition in minerals from NWA480.

NWA480 contains "melt pockets", as well as maskelynite and stishovite (Barrat *et al*. 2002), indicating that it has been shocked.

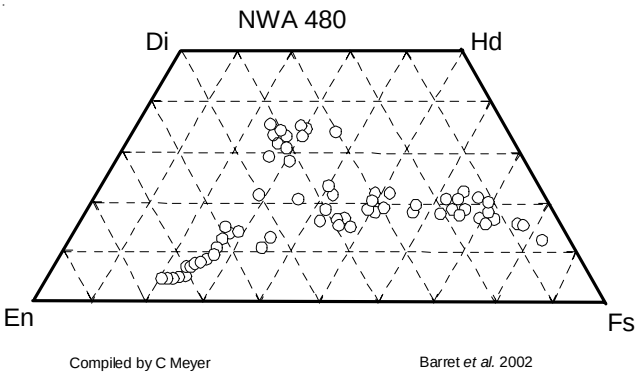

***Figure 2**: Pyroxene quadrilateral for NWA 480 (data replotted from Barrat et al. 2002).*

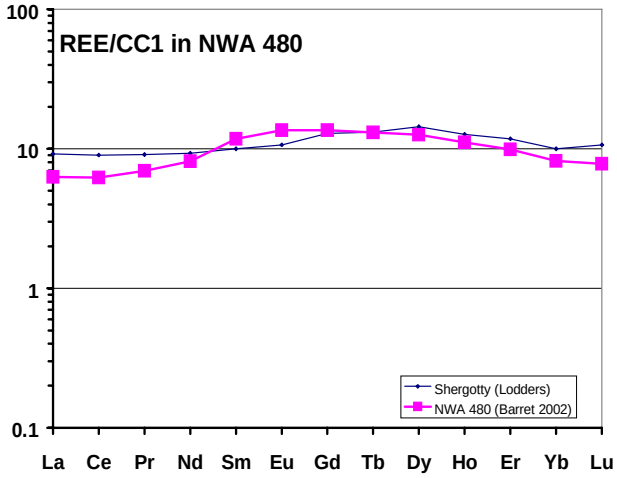

***Figure 3**: Normalized rare earth element diagram for NWA 480 and Shergotty (data from Barrat et al. 2002 and Lodders 1998).*

Mineralogical Mode

	Barrat *et al.* (2002)
Pyroxene	72 vol. %
Plagioclase	25
Phosphate	1
Opaques	1

Photos of this sample can also be seen at http://www.jpl.nasa.gov/snc/nwa480.html

Mineral Chemistry

Pyroxenes: Pyroxenes in NWA 480 (figure 2) are complexly zoned with Mg-rich cores ($En_{77}Fs_{20}Wo_3$-$En_{65}Fs_{29}Wo_6$), surrounded by Mg-rich augite ($En_{41}Fs_{29}Wo_{30}$) and finally zoned to Fe-rich pigeonite ($En_5Fs_{84}Wo_{11}$). There is no exsolution in the pyroxene except for the most Fe-rich.

Maskelynite: All of the plagioclase has been shocked to form maskelynite ($An_{46\text{-}50}Ab_{52\text{-}48}Or_{2)}$.

Phosphates: Both merrillite and chlor-apatite are present in NWA 480. Fayalite-silica symplectite intergrowth is illustrated surrounding merrillite in figure 7 of Barret *et al.* (2002).

Oxides: Analyses of ilmenite and chromite are given in Barret *et al.* (2002).

Sulfide: Lorand et al. (2006) determined that the sulfide in NWA480 was pyrrhotite and give an analysis.

Silica: Silica grains found included in maskelynite have been found to be a mixture of high-pressure silica glass and stishovite by Raman spectroscopy and cathololuminescence (Barrat *et al.* 2002, Chennaoui Aoudjehane et al. 2005).

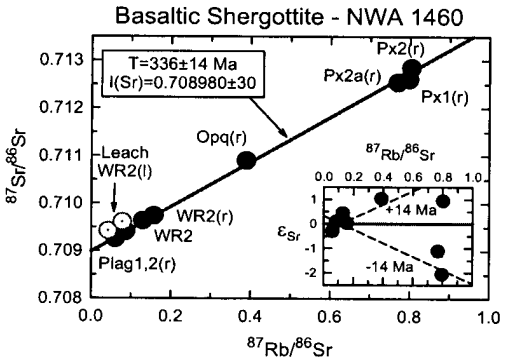

***Figure 4:** Rb-Sr isochron for NWA 1460 (Nyquist et al. 2006).*

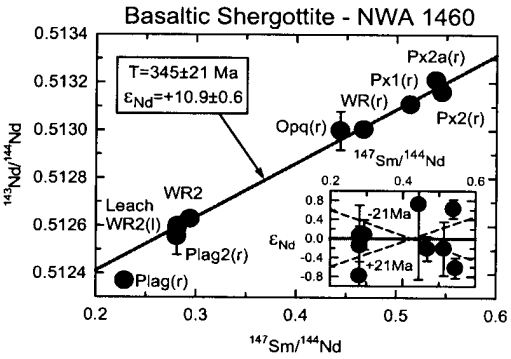

***Figure 5:** Sm-Nd isochron for NWA 1460 (Nyquist et al. 2006).*

Note: Crozaz et al. (2001) have determined the REE pattern of pyroxenes, apatite and merrillite in NWA 480. The low-Ca pyroxenes are found to have 'elevated La' – presumably due to terrestrial contamination, despite the fresh appearance of this meteorite.

Table XVIII: Composition of NWA 480.

reference	Barrat 2002	
weight	182 mg.	
SiO2 %		
TiO2	1.16	(a)
Al2O3	6.46	(a)
FeO	19.44	(a)
MnO	0.51	(a)
CaO	9.32	(a)
MgO	10.06	(a)
Na2O	1.26	(a)
K2O	0.1	(a)
P2O5		
sum		
Li ppm	2.93	(b)
Be	0.21	(b)
Sc	28	(b)
V	202	(b)
Cr	2121	(a)
Co	37.6	(b)
Ni	63	(b)
Cu	17.6	(b)
Zn	64	(b)
Ga	16.27	(b)
Ge		
Rb	2.67	(b)
Sr	49.3	(b)
Y	16.46	(b)
Zr	58.74	(b)
Nb	1.99	(b)
Cs ppm	0.19	(b)
Ba	28.4	(b)
La	1.48	(b)
Ce	3.77	(b)
Pr	0.619	(b)
Nd	3.7	(b)
Sm	1.73	(b)
Eu	0.76	(b)
Gd	2.67	(b)
Tb	0.477	(b)
Dy	3.05	(b)
Ho	0.62	(b)
Er	1.57	(b)
Tm		
Yb	1.33	(b)
Lu	0.19	(b)
Hf	1.64	(b)
Ta	0.1	(b)
W ppb	340	(b)
Th ppm	0.22	(b)
U ppm	0.064	(b)

technique (a) ICP-AES, (b) ICP-MS

Figure 6: *Copyrighted photograph of NWA 1460 taken by Nelson Oakes showing nearly complete fusion crust.*

Figure 7: *Photograph of sawn surface of NWA 1460 showing basaltic texture similar to that of NWA 480. Photo by Nelson Oakes.*

Whole-rock Composition

The chemical composition of NWA 480 is reported by Barrat *et al*. (2001, 2002) (Table 1). The REE pattern (figure 3) was found to be "similar" to ALH77005 – which is a lherzolitic shergottite. It is thought that this basalt may link the origins of the two basic types of shergottite (Barrat *et al.*, Crozaz *et al*. 2001).

NWA 480 has normal Th/U, Ba/La and Sr/Nd ratios similar to Antarctic Martian meteorites, indicating that it is a fresh meteorite, free of the effects of terrestrial weathering (Barrat *et al*. 2002).

Radiogenic Isotopes

Nyquist et al. (2006) have dated NWA1460 by Rb-Sr and Sm-Nd (336 ± 14 b.y. and 345 ± 21 b.y.)(figures 4 and 5).

Cosmogenic Isotopes and Exposure Ages

Marty *et al*. (2001) report an "average exposure age" of 2.4 ± 0.2 m.y. Nishiizumi et al. (2004) reported a ^{10}Be exposure age of 2.2-3 m.y. for pieces of NWA1460

Other Isotopes

Barrat *et al*. (2001, 2002) determined the isotopic composition of oxygen as ä^{17}O = 2.91‰, ä^{18}O = 4.78‰, with $\Delta^{17}O$ = +0.42 ‰.

Nishiizumi et al. (2004) determined ^{10}Be and ^{41}Ca on NWA1460.

Processing

Photos of NWA480 and NWA1460 show that they were both first sliced by a saw cut across one end (figure 1 and 7). Other than that, I've not been able to learn much about how they were cut and subdivided.